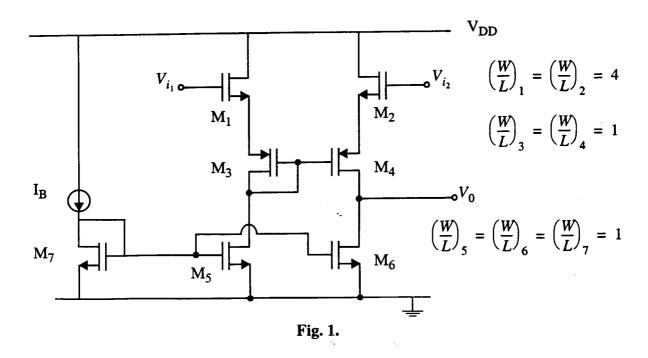
## University of California College of Engineering Department of Electrical Engineering and Computer sciences

EE140	Midterr	n Exam	Mar. 13, 2003
Name:		SID#:	
grad [		undergrad	
<ul> <li>Closed book except for</li> <li>There are two problems.</li> </ul>	1 - 8.5" x 11" sheet of Be sure to show all	your notes. your work to receive fu	ll or partial credit.
	1		
	2		
	Total		



- 1) In the amplifier of Fig. 1, assume all NMOS devices have  $V_T = V_{T_n}$ , and all PMOS devices have  $V_T = V_{T_p}$ . You may neglect body effect. Further, assume all devices are minimum length, and are characterized by  $k'_n$ ,  $\lambda_n$  and  $k'_p$ ,  $\lambda_p$  for NMOS and PMOS devices respectively.
  - a) (10 pts.) For the nominal input  $V_{i_1} = V_{i_2} = V_{DD}$ , determine the circuit operating point. Fill in the data below in terms of symbolic parameters.  $V_{T_n}$ ,  $V_{T_p}$ ,  $k'_n$ ,  $k'_p$ ,  $\lambda_n$ ,  $\lambda_p$ ,  $I_B$ ,  $\left(\frac{W}{L}\right)$  's, etc.

$I_{D_1}$	
$I_{D_2}$	
$V_{S_1}$	
$V_{S_2}$	
$V_{D_3}$	
$V_0$	

**b**) (10 pts.)

Determine the common mode input range, consistent with keeping all devices active.

**c)** (10 pts.)

If  $V_{i_2} = V_{DD}$ , determine the output range, consistent with keeping all devices active.

**d)** (10 pts.)

For the operating point with  $V_{I_1} = V_{I_2} = V_{DD}$ , determine the differential mode circuit

$$G_{\text{m}}$$
, i.e.  $G_{m_{diff}} = \frac{i_{out}}{(v_{i_1} - v_{i_2})}$ .

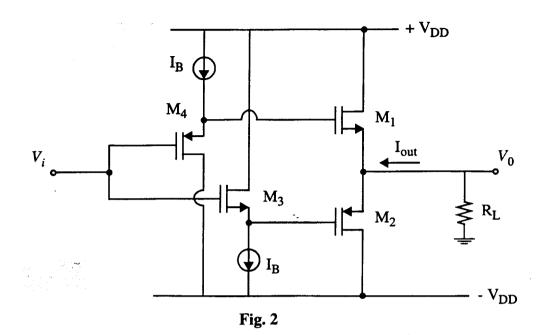
**e**) (10 pts.)

For the operating point with  $V_{i_1} = V_{i_2} = V_{DD}$ , determine  $R_{out}$ .

f) (10 pts.)

(10 pts.)

Determine the common mode gain, i.e.  $A_{v-cm} = \frac{v_0}{v_{in}} \Big|_{v_{i_1} = v_{i_2} = v_{in}}$ .



2) For the circuit of Fig. 2, take the following:  $\left(\frac{W}{L}\right)_1 = N\left(\frac{W}{L}\right)_3$ ;  $\left(\frac{W}{L}\right)_2 = N\left(\frac{W}{L}\right)_4$ ;  $k'_n\left(\frac{W}{L}\right)_3 = k'_p\left(\frac{W}{L}\right)_4$ . Neglect body effect and channel length modulation. Assume  $V_{T_n} = V_{T_p}$ .

a) (10 pts.) For  $V_i = 0$  and  $R_L = \infty$ , determine  $V_0$ ,  $I_{D_1}$  and  $I_{D_2}$ .

$V_0$	
$I_{D_1}$	
$I_{D_2}$	

b) (10 pts.) For the bias condition determined in part (a), determine the circuit  $G_{\rm m}$ .

c) (10 pts.) For the bias condition determined in part (a), determine  $R_{out}$ .

**d)** (10 pts.)

Take  $V_i = 0$  and  $R_L = \infty$ . Determine the large signal  $I_{\text{out}}$  -  $V_0$  curve obtained by applying an appropriate test source at the circuit output.